

Topic 18: Variation and Selection

18.1 Variation

Variation is defined as the differences between individuals of the same species.

Types of Variation

Feature	Continuous Variation	Discontinuous Variation
Phenotypes	Shows a range of phenotypes between two extremes.	Has a limited number of phenotypes with no intermediates.
Examples	Body length, body mass, height, leaf size.	ABO blood groups, seed shape, seed colour, ability to roll tongue.
Cause	Both genes and the environment.	Mainly genes only.
Effect on Graph	Forms a normal distribution curve (bell-shaped curve).	Forms a bar chart (discrete categories).

Sources of Genetic Variation

Genetic variation within a population is essential for evolution and is generated by several processes:

- 1 **Mutation:** A genetic change defined as a **random change in the base sequence of DNA**.
 - Mutation forms **new alleles**.
 - The rate of mutation can be increased by **ionising radiation** (e.g., X-rays, UV light) and some **chemicals** (mutagens).
- 2 **Meiosis:** The cell division process that produces gametes, which introduces variation.
- 3 **Random Mating:** The random choice of partners for sexual reproduction.
- 4 **Random Fertilisation:** The random fusion of gametes (sperm and egg) during sexual reproduction.

18.2 Adaptive Features

An **adaptive feature** is an **inherited feature** that helps an organism **survive and reproduce** in its environment.

Adaptations in Plants (Extended)

Organisms adapt to their specific environments. Two key examples are aquatic and desert plants:

Plant Type	Environment	Adaptive Features	Explanation
Hydrophytes	Wet, aquatic environments.	1.Large air spaces in stems/leaves; 2.stomata on the upper surface; 3.reduced root system.	1.Provides buoyancy 2.Maximizes gas exchange 3.Roots are not needed for water absorption.
Xerophytes	Dry, desert environments.	1.Thick waxy cuticle; small leaves/spines 2.Rolled leaves; sunken stomata 3.deep or widespread roots	1.Reduces water loss by transpiration 2.Traps moist air (reducing transpiration) 3.Maximizes water absorption.

18.3 Selection

Adaptation and Natural Selection (Evolution)

Natural selection is the process by which populations become more suited to their environment. Over many generations, this process leads to adaptations. This process involves four key steps:

- 5 **Genetic Variation:** Individuals within a population show a wide range of variation in their characteristics due to mutation, meiosis, and random fertilisation.
- 6 **Production of Many Offspring:** Organisms produce more offspring than the environment can support, leading to a **struggle for survival** (competition for resources, avoiding predators).
- 7 **Survival of the Fittest:** Individuals with characteristics that make them **better adapted** to the environment are more likely to survive and reproduce successfully.
- 8 **Advantageous Alleles Passed On:** The better-adapted individuals pass on their **advantageous alleles** to the next generation, leading to an increase in the frequency of these alleles in the population over time.

Example: Antibiotic-Resistant Bacteria The development of antibiotic resistance is a classic example of natural selection:

- 9 **Variation:** A population of bacteria contains a few individuals with a random mutation that makes them resistant to an antibiotic.
- 10 **Selection Pressure:** When the antibiotic is used, the non-resistant bacteria are killed (**struggle for survival**).
- 11 **Survival:** The resistant bacteria survive and reproduce rapidly (as there is less competition).
- 12 **Inheritance:** The new population is now largely made up of resistant bacteria, making the antibiotic ineffective.

Artificial Selection (Selective Breeding)

Artificial selection, or selective breeding, is the process by which humans choose organisms with desirable traits and breed them together over many generations to enhance those traits.

Feature	Natural Selection	Artificial Selection
Selection Agent	The environment (nature).	Humans.
Purpose	Survival and reproduction of the species.	To produce organisms with features desirable to humans (e.g., high yield, disease resistance).
Speed	Very slow (over thousands of generations).	Relatively fast (over tens to hundreds of generations).
Outcome	Leads to adaptation and the evolution of new species.	Leads to new varieties or breeds of existing species.
Genetic Diversity	Generally maintains or increases genetic diversity	Often drastically reduces genetic diversity due to selective breeding and inbreeding.

Outline of Artificial Selection:

- 13 **Selection:** Humans select individuals with the most desirable features (e.g., the cow that produces the most milk).
- 14 **Crossing:** These selected individuals are crossed (bred) together.
- 15 **Offspring Selection:** The offspring are assessed, and only those showing the desired traits are selected to breed for the next generation.
- 16 **Repetition:** This process is repeated over many generations until the desired trait is strongly expressed.